Understanding Resistance to Invasion and Resilience to Disturbance – Importance for Restoring and Managing Great Basin Rangelands

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Resistance, Resilience and Thresholds

- Resilience = the capacity of an ecosystem to regain characteristic processes over time following stress or disturbance

- Thresholds are crossed when an ecosystem does not return to the original state via natural processes following disturbance, and requires active management to restore

Resistance, Resilience and Thresholds

- Resistance = the ability of an ecosystem to maintain characteristic processes despite various stressors or disturbances

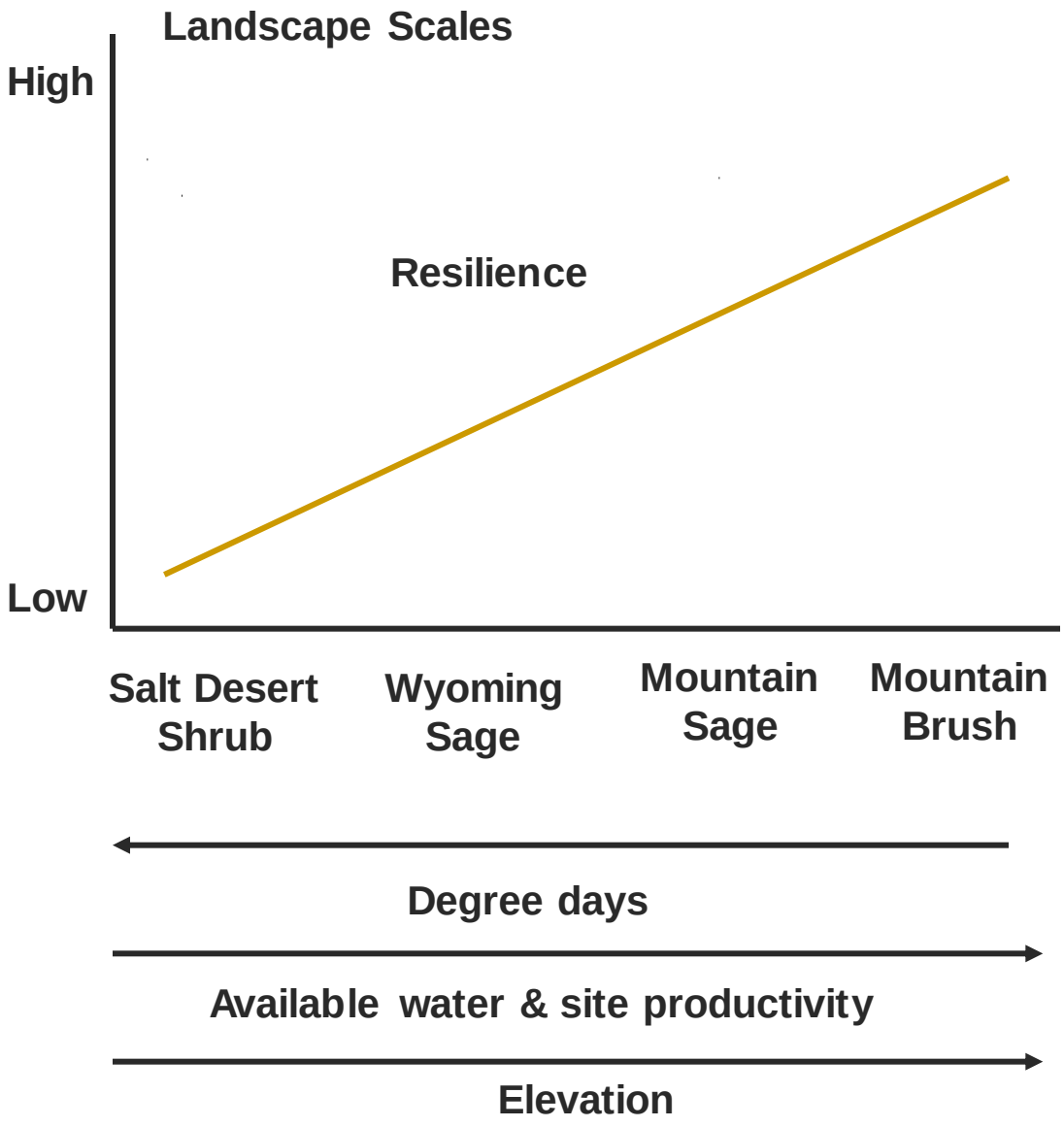
- Resistance to invasives = the biotic and abiotic factors and ecological processes in an ecosystem that limit the population growth of an invading species

Great Basin Vegetation Types

4’’ 12’’ 24 +’’

Annual Precipitation

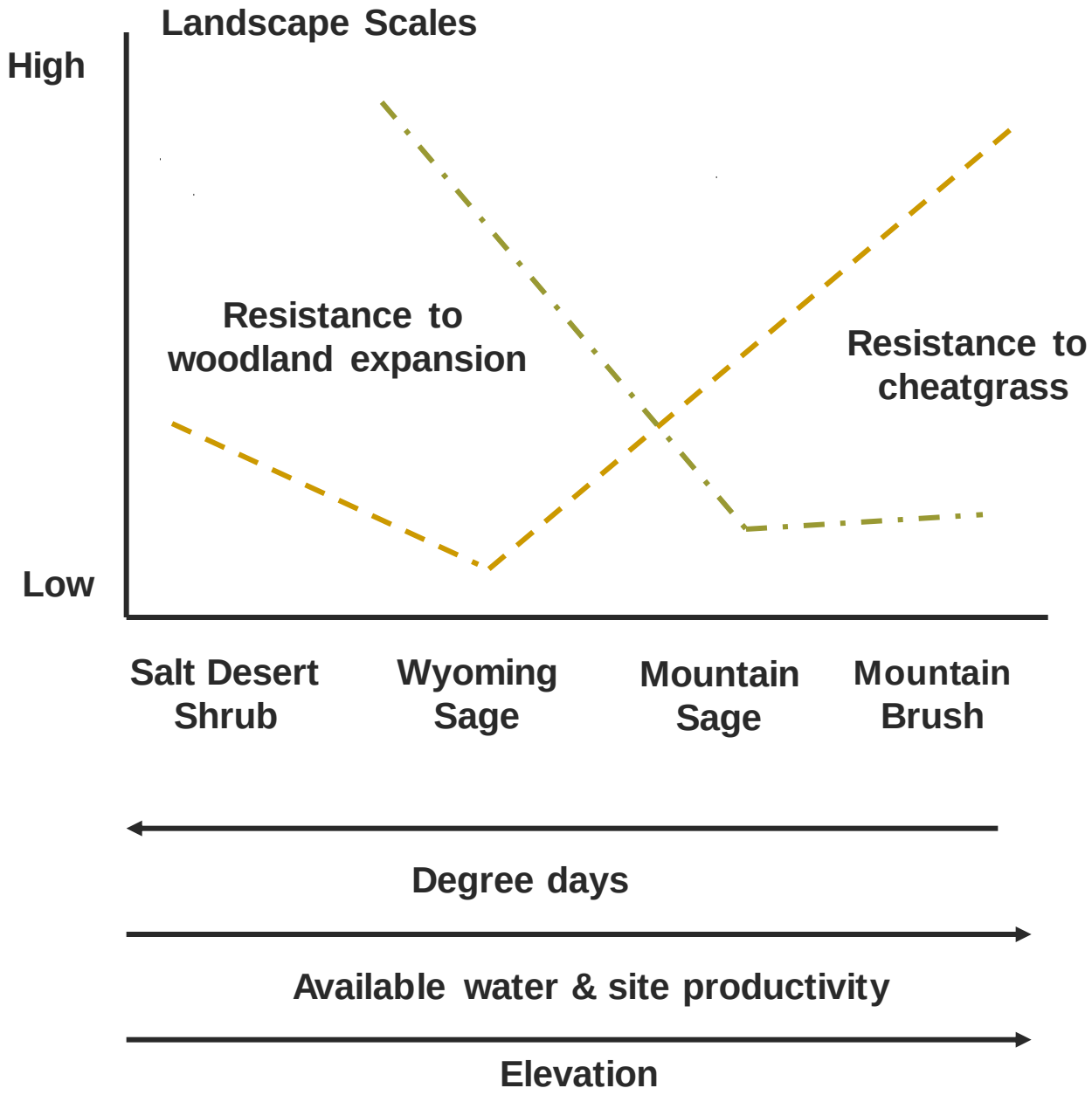
Tigercat



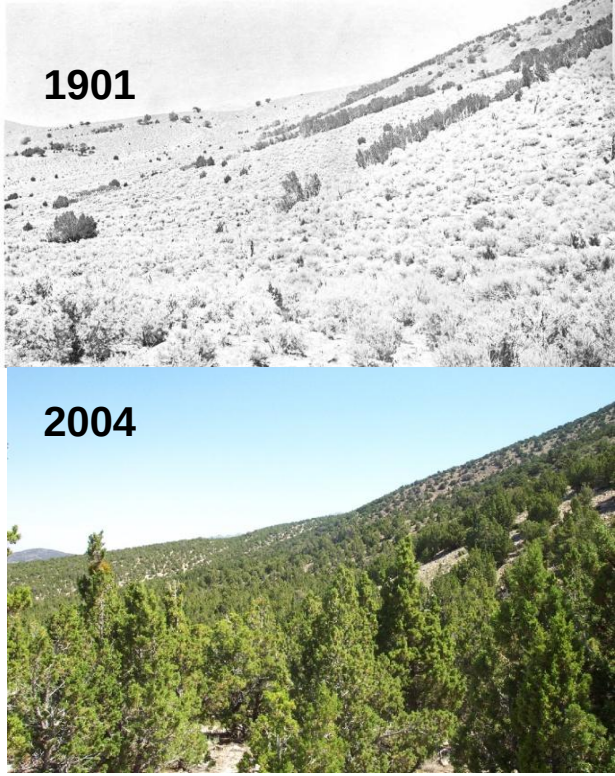
(Wisdom & Chambers 2009)

Resilience increases with elevation over gradients of available resources and net productivity

- Higher productivity & more favorable growing conditions
- More rapid recovery after disturbance
- Increased capacity to compete with invaders



(Wisdom & Chambers 2009)



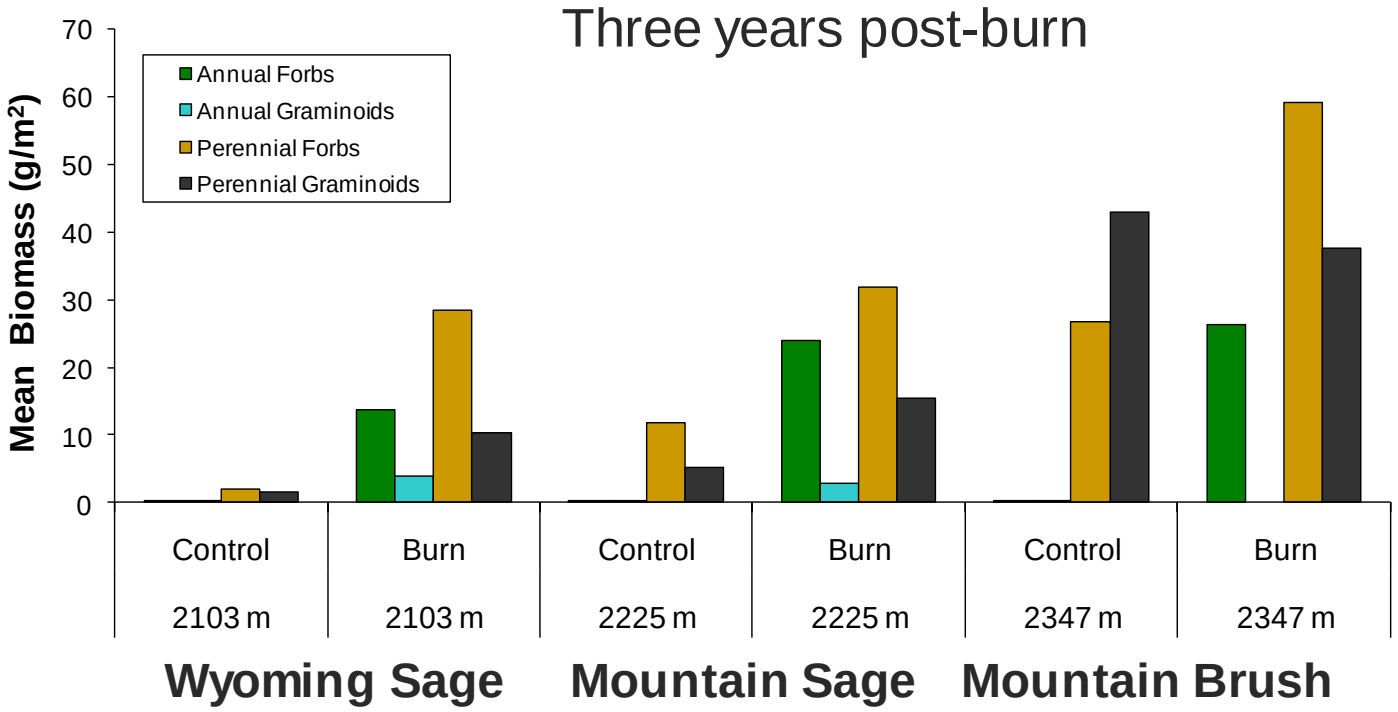
Resistance to invasive species reflects their ecological amplitude

- Resistance is higher in stressful environs
- Historically, Wyoming sage least resistant to cheatgrass
- Mountain sage least resistance to trees

Factors that Influence Resistance and Resilience at Local Scales

- Ecological memory –
  - Site potential as indicated by soils and precipitation
  - Species composition and ecological condition as indicated by native seed banks and seed sources, and residual plants and animals
  - Presence, abundance & type of invasive species
- Severity and frequency of disturbance -
  - Inappropriate livestock grazing, high intensity fires, and fire return intervals less than the historical interval

Effect of Fire and Elevation



Intermediate Tree Cover (~30 to 40%)

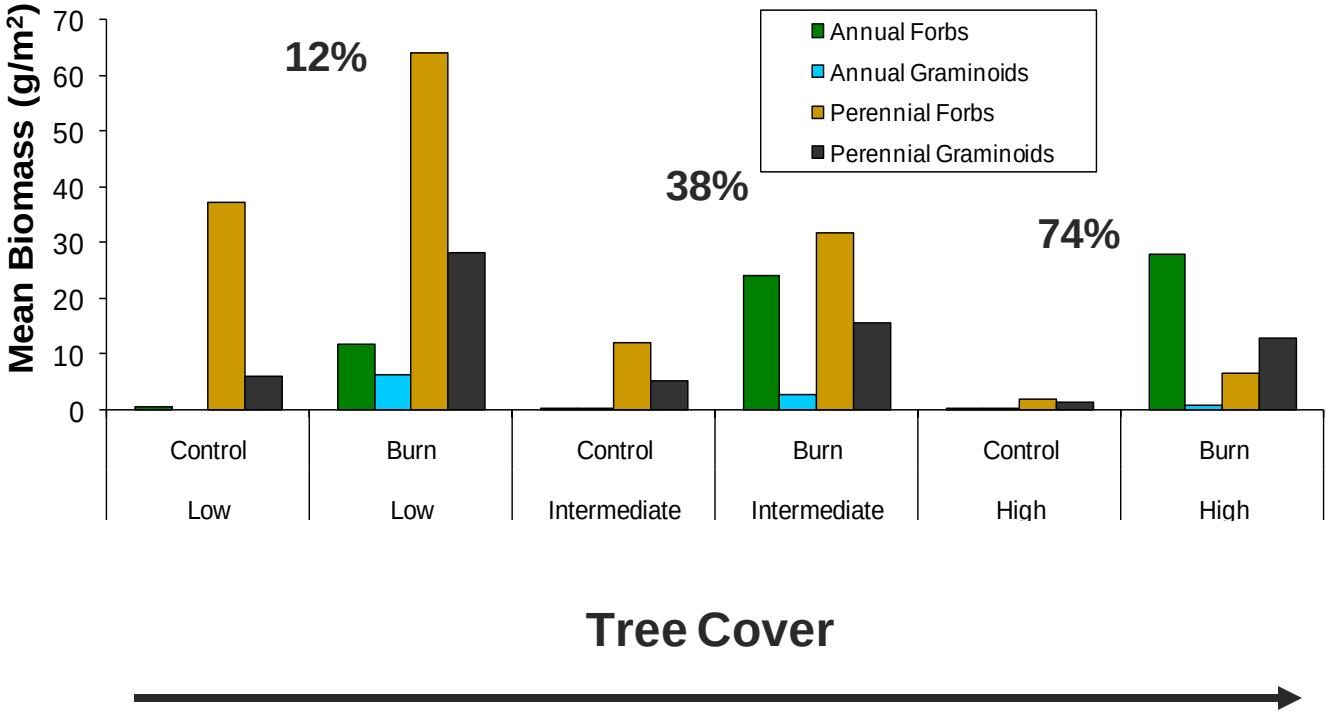
(Dhaemers & Chambers in process)

Productivity & site potential change with elevation

- Herbaceous biomass increases with elevation both pre- and post burn
- Higher productivity can result in greater resilience and resistance

Effect of Tree Cover and Fire

Three years post-burn

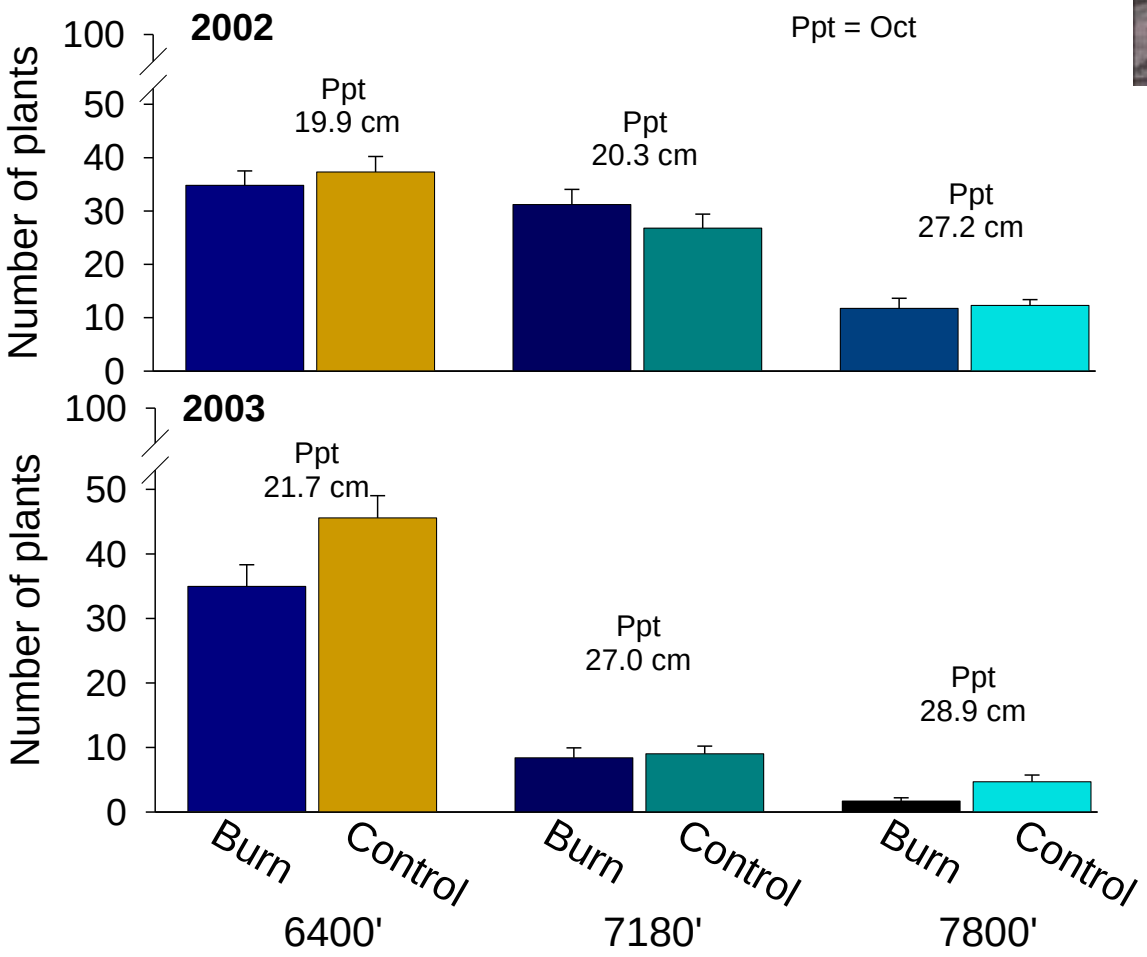


Ecological memory decreases with increasing tree cover

- Perennial herb biomass decreases with tree cover both pre- and post burn
- Annual herb biomass increases with tree cover
- Resistance and resilience decrease as tree cover increases

(Dhaemers & Chambers in process)

Effect of Elevation, Herbaceous Species and Fire

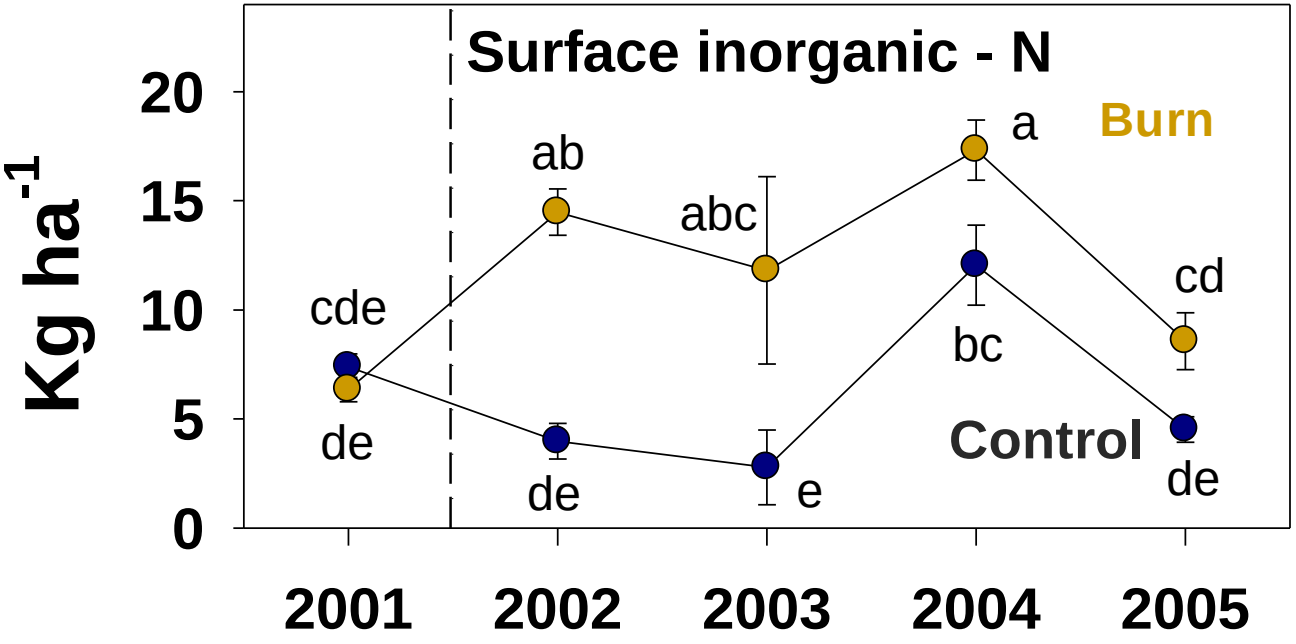


Ecological resistance increases with elevation

- Higher elevations and colder soil temperatures result in ecophysiological constraints
- Site characteristics and growing season conditions have greater effects on establishment than fire or herbaceous species removal

(Chambers et al. 2007)

Effect of Fire on Soil Nitrogen

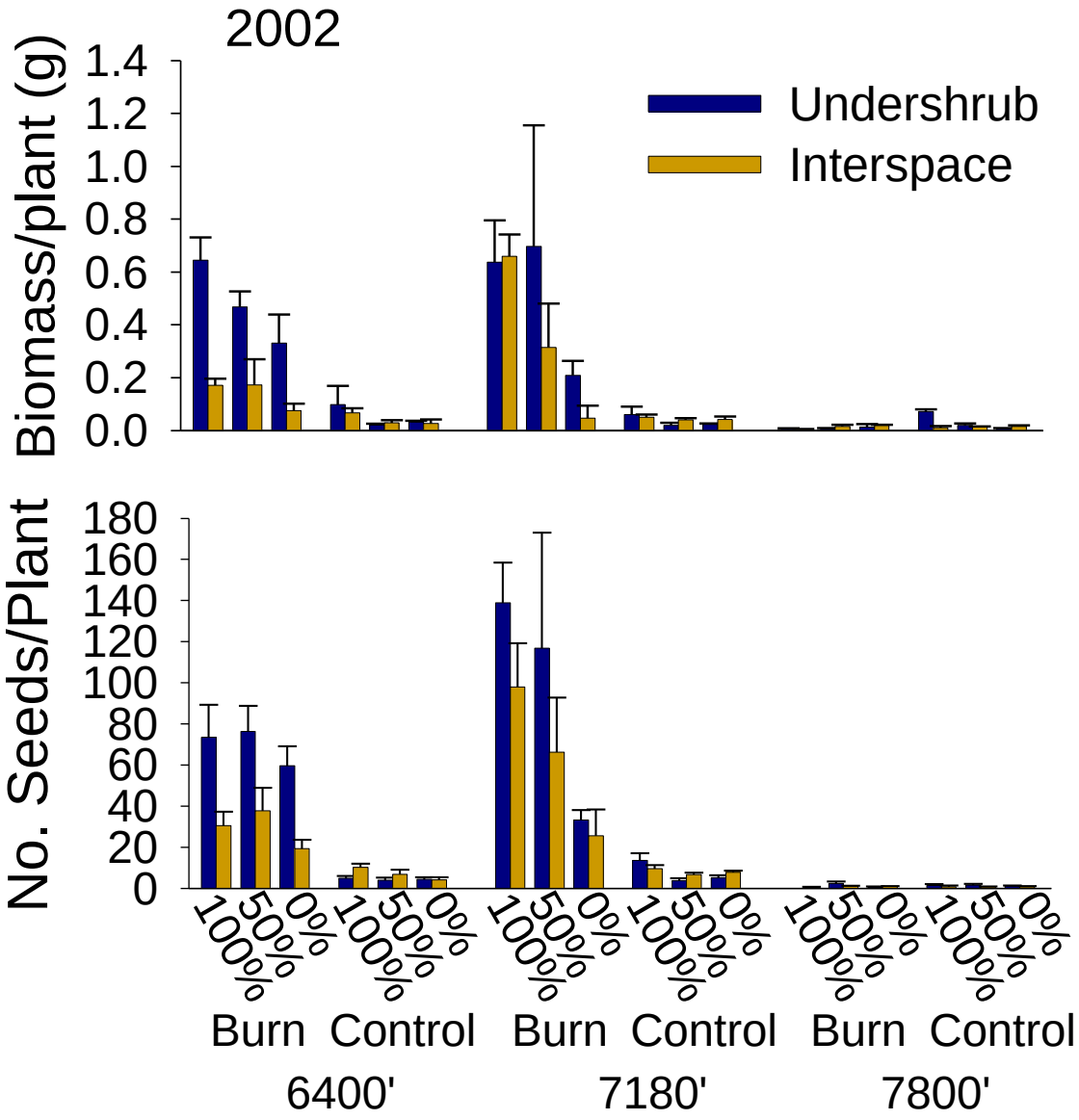


Available soil nitrogen increases after fire

- Available nitrogen higher on burn than control
- Effect lasted 3 years
- Fertilization effect of ~80-100 lbs/acre of available nitrogen

(Rau et al. 2007)

Effect of Elevation, Herbaceous Species and Fire

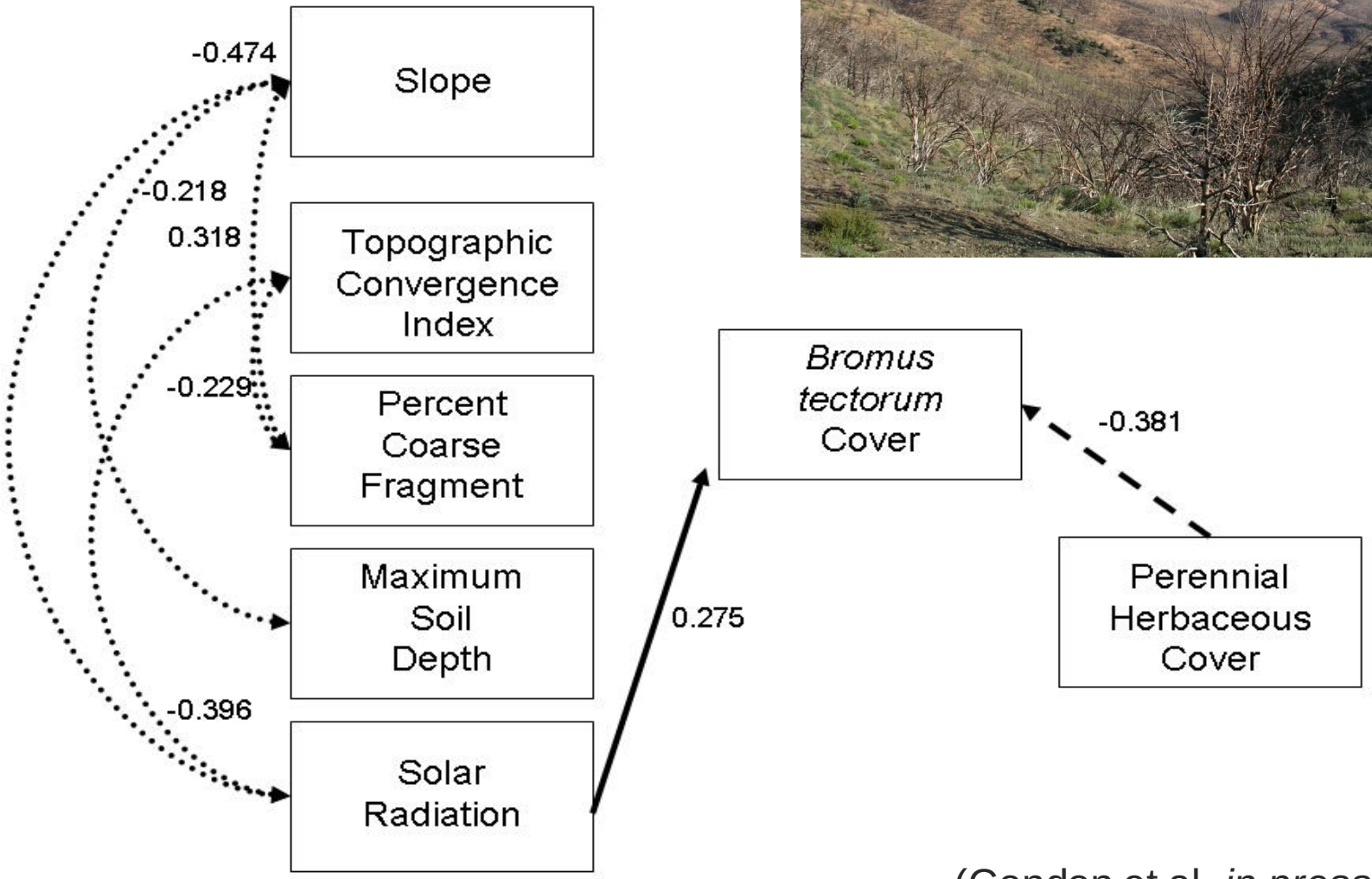


Effects of burning and removal on growth and reproduction are additive & similar over elevations

- Removal – 2 to 3 fold
- Burning – 2 to 6 fold
- Removal + Burning – 10 to 30 fold

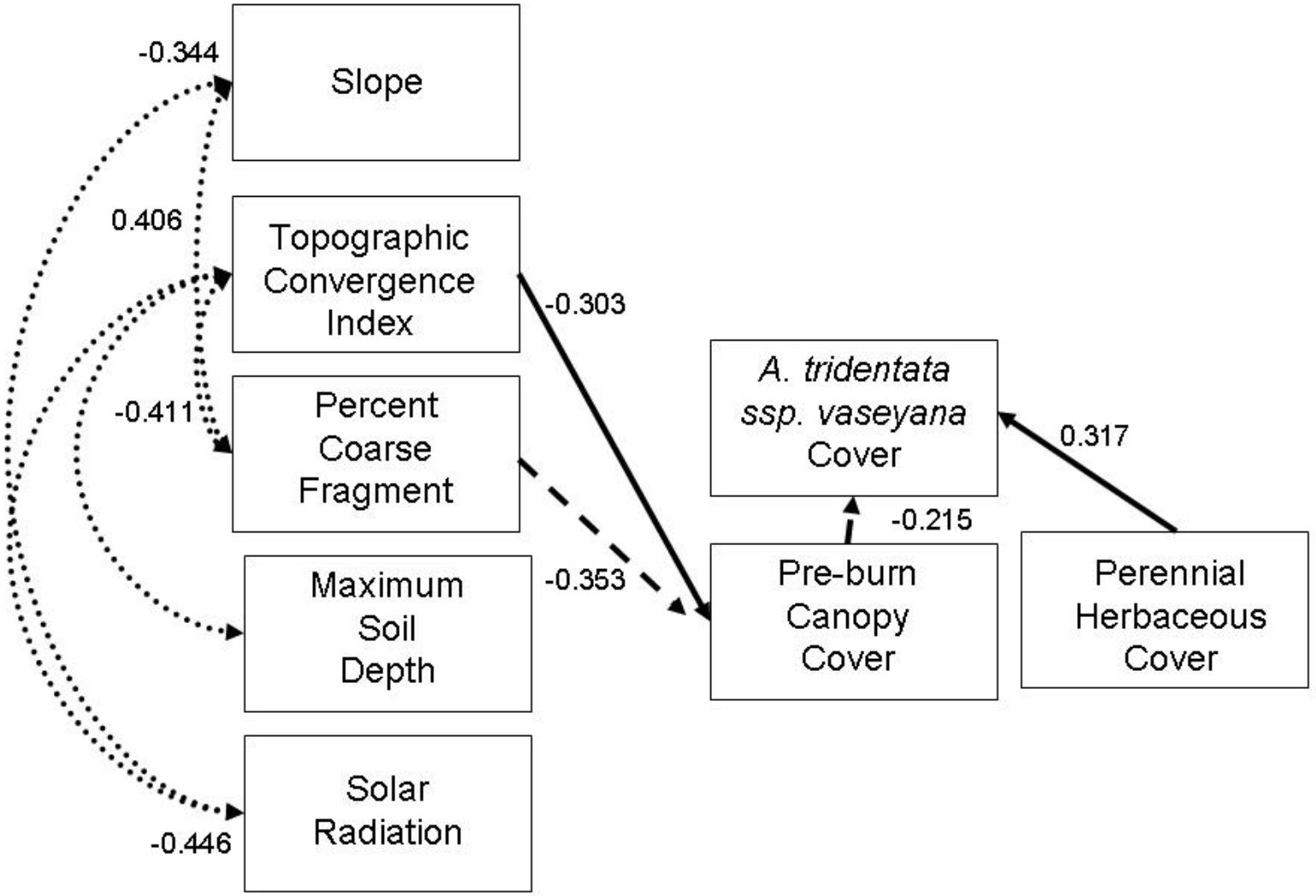
- Disturbances that increase resources decrease resistance
- Mechanism is growth and reproduction after establishment
- Perennial herbaceous species increase resistance via competition for resources

Landscape Level Controls on *Bromus tectorum*

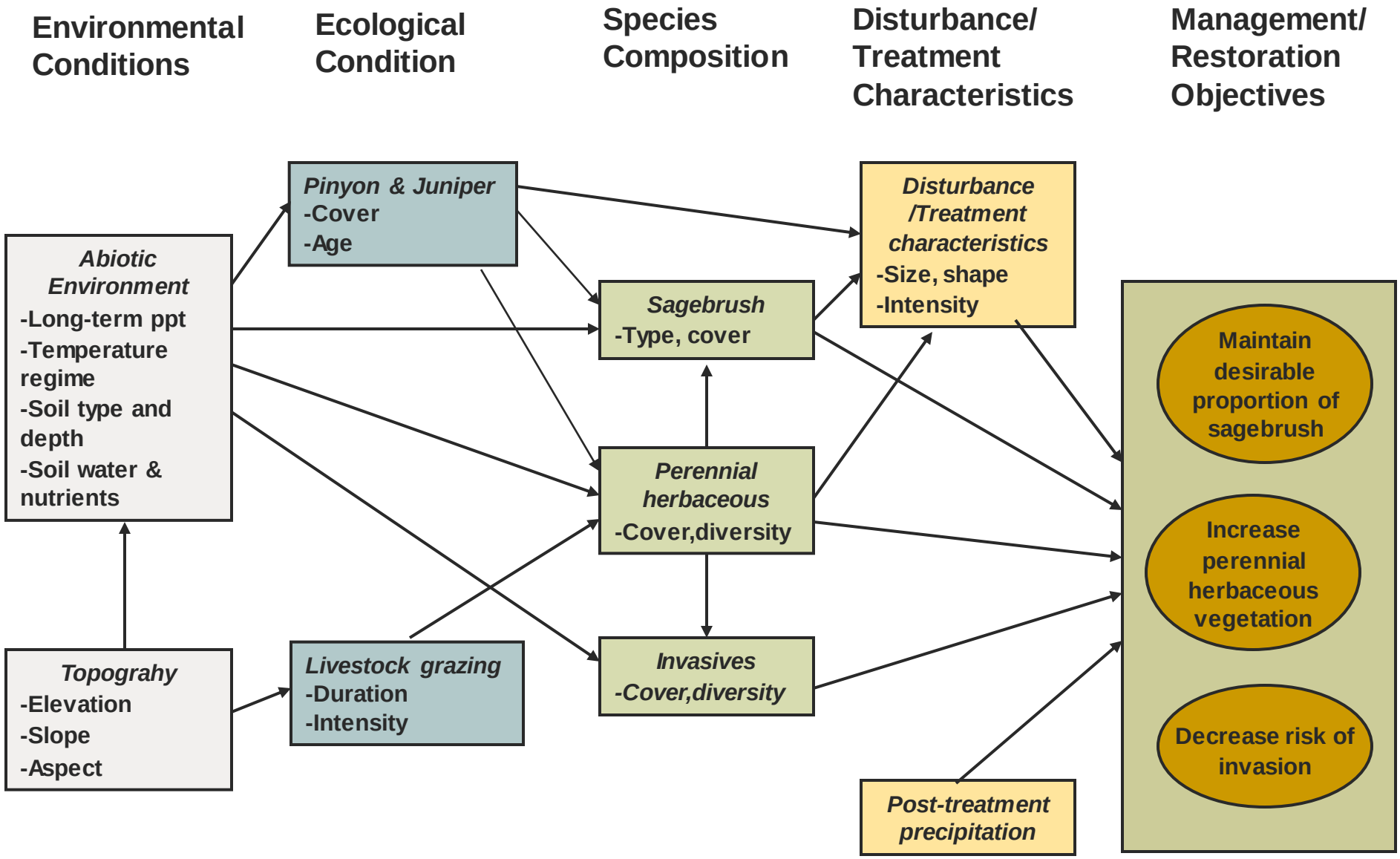


(Condon et al. *in press*)

Landscape Level Controls on *A. tridentata*



(Condon et al. *in press*)


Environmental Conditions
Ecological Condition
Species Composition
Disturbance/ Treatment Characteristics
Management/ Restoration Objectives
Abiotic Environment
-Long-term ppt
-Temperature regime
-Soil type and depth
-Soil water & nutrients
Topograhy
-Elevation
-Slope
-Aspect
Pinyon & Juniper
-Cover
-Age
Livestock grazing
-Duration
-Intensity
Sagebrush
-Type, cover
Perennial herbaceous
-Cover,diversity
Invasives
-Cover,diversity
Disturbance /Treatment characteristics
-Size, shape
-Intensity
Post-treatment precipitation
Maintain desirable proportion of sagebrush
Increase perennial herbaceous vegetation
Decrease risk of invasion

Management Approach

- A basic approach for managing and restoring these ecosystems using the concepts of resistance and resilience includes:

  - First → assess environmental characteristics, vegetation types and ecological conditions at landscape scales.
  - Second → develop an understanding of ecological resistance and resilience and relationship to thresholds for the ecosystems of interest (e.g. Stagestep.org).
  - Third → prioritize management activities at landscape scales. Categories include Protection, Prevention and Restoration/Rehabilitation.

Protection

- Protect areas with inherently low resistance or resilience like lower elevation salt desert and Wyoming sage types, areas of high conservation value, and areas at risk of crossing ecological thresholds.
- Focus on -
  - Eliminating stressors like repeated fire and inappropriate livestock grazing.
  - Controlling surface disturbances and invasion corridors.
  - Increasing efforts to detect and eradicate exotic species at the early stages of invasion.

Preventative Management

- Maintain or increase resistance and resilience in areas that have declining ecological conditions or that are in the initial stages of cheatgrass invasion or tree expansion.
- Eliminating stressors still high priority.
- Focus should be on areas with higher inherent resilience.
  - Objectives include increasing herbaceous perennials through competitive release from shrubs and trees, and reducing woody fuel loads to minimize risk of high severity fire.
  - Treatments can include prescribed fire, mechanical shrub or tree thinning, or herbicides.

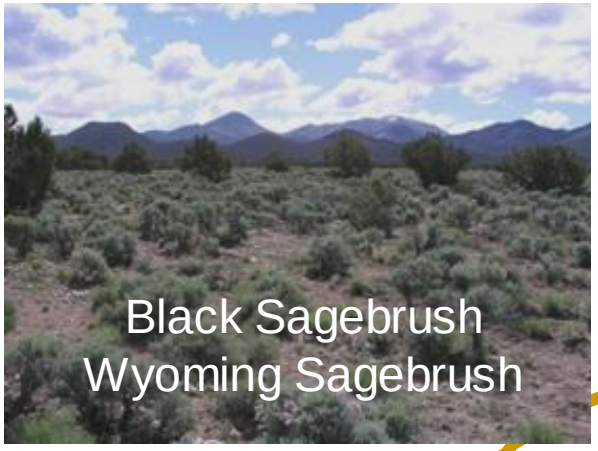
Restoration or Rehabilitation

- Restoring or rehabilitating areas that have crossed thresholds is lower priority. Exceptions include:
  - ESR or BAER seeding in areas with depleted grasses and forbs.
  - Areas adjacent to intact vegetation communities that can serve as buffers or fire breaks.
  - Wildland-urban interface.
  - Endangered ecosystems.
  - Critical habitat for T&E species.

Restoration or Rehabilitation

- Restoration or rehabilitation seeding offers an opportunity to increase resilience and resistance
- Seeding species that differ in life form, rooting depth and phenology has multiple benefits:
  - Higher resource use and increased competition with invaders
  - Greater capacity of community to persist following disturbances that result in mortality of vulnerable species
  - Structural diversity to support animal species
- Seeding species that are adapted to a changing climate can help prevent surprises
  - Predictions are for a warmer and drier climate

Case Study –
North Monitors Tree Expansion



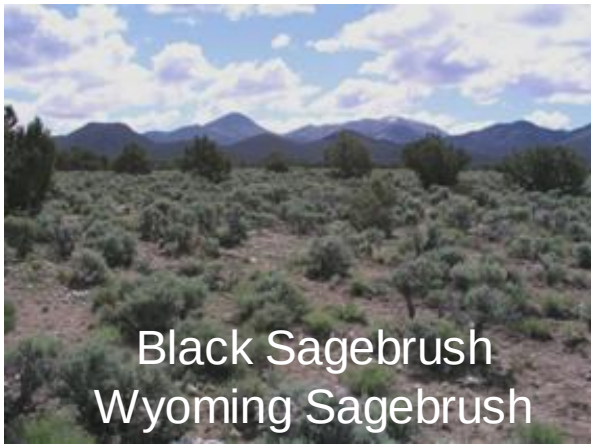
10”

14”

18”

Resilience

Resistance



Resilience & Resisistance

- Elevation – relatively low
- Precipitation &productivity - moderately low
- Ecological condition – fair
- Abundance of invasives – cheatgrass present; locally abundant
- Grazing – allotment vacant

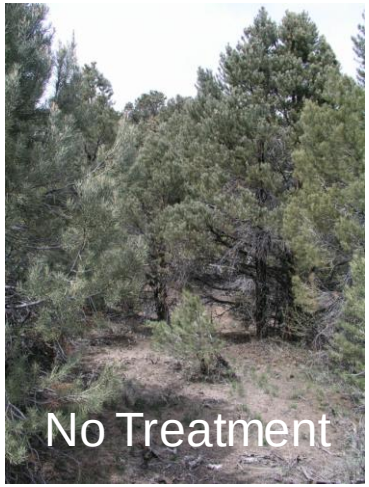
Management Implications

- Slower recovery due to low productivity
- Higher risk of cheatgrass spread, especially after fire
- Lack of fine fuels

➢ Use mechanical treatments

➢ Minimize surface disturbance

➢ Manage grazing



Resilience & Resilience

- Elevation – intermediate
- Precipitation &productivity -moderate
- Ecological condition – fair/low
- Abundance of invasives – cheatgrass present; locally abundant
- Grazing – allotment active

Management Implications

- Low recovery due to high tree cover & depleted understory
- Higher risk of cheatgrass spread, especially on South slopes
- Higher risk of severe fire
- ➢ Treat areas with low tree abundance – use mechanical methods
- ➢ Create fuel breaks
- ➢ Revegetate following fire
- ➢ Manage grazing

Resilience & Resilience

- Elevation – high
- Precipitation &productivity -moderately high
- Ecological condition – good
- Abundance of invasives – cheatgrass largely absent
- Grazing – allotment active

Management Implications

- Higher recovery rates
- Lower risk of cheatgrass spread
- Lower risk of severe fire
- ➢ Treat with prescribed fire
- ➢ Manage grazing

- ❖ Monitor results – adapt management

The Road Forward

- Great Basin ecosystems are undergoing rapid, large-scale and often undesirable changes.

- Prioritizing restoration and management activities based on resistance and resilience may be an important step to:
  - Increase sustainability
  - Maintain ecosystem services
  - Provide for species of concern
  - Adapt to a changing climate

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